Results of ^{226}Ra + ^{48}Ca Experiment

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Introduction

Results of the experiment performed at the Dubna Gas Filled Recoil Separator and aimed at the synthesis and study of the ^{226}Ra + ^{48}Ca complete fusion reaction products are presented. The measured cross section for the 4n de-excitation channel is discussed. The measured value is compared with the theoretical calculations.

Experimental Technique

Evaporation residues recoiling from the target (^{226}Ra, 0.23 and 0.36 mg/cm^2 – two runs) were separated in flight from the primary beam, scattered target and beam particles, and various transfer-reaction products by the Dubna Gas-Filled Recoil Separator [1], consisting of dipole magnet and two quadrupole lenses. A rotating entrance window (1.5 μm Ti foil; Fig.1) separated the hydrogen-filled volume of the separator (at a pressure of 1 Torr) from the vacuum of the cyclotron beam line.

The recoils passed through a Mylar window (about 1 μm), which separated the hydrogen-filled volume of the separator from the detecting module filled with pentane (at about 1.5 Torr) and then through a time-of-flight (TOF) system and were finally implanted in the detector array installed in the focal plane of the separator. The TOF detector was used to measure the time of flight of recoiling nuclei and to distinguish the signals arising in the focal plane detector due to particles passing trough the separator from those due to the radioactive decay of previously implanted nuclei.

Alpha-energy calibrations were periodically performed using the alpha peaks from nuclides, produced in the bombardments of ^{nat}Yt target with ^{48}Ca ions.

For detection of the daughter nuclides in the absence of beam-associated background, the beam was switched off after a recoil signal was detected with implantation energy E_{ER}=9-15 MeV expected for complete-fusion evaporation residues, followed by an α-like signal with an energy of 9.0 MeV≤ E_α ≤9.38 MeV in the same strip, within a 2.2-mm wide position window and a time interval of Δt≤8 s. However, for reducing the number of beam interruptions and collecting larger beam dose the most part of the first experiment (about three fourth) at E_{lab}=233.5 MeV with 0.23-mg/cm^2 target was performed without switching the beam off. Other part of experiment at E_{lab}=233.5 MeV, as well as both experiments at E_{lab}=228.5 MeV were performed with 3-min beam-off intervals. In the experiment at high ^{48}Ca energy duration of beam-off time interval was 1 min, but if an α particle with E_α=8.5-9.1 MeV was registered in any position of the same strip, the beam-off interval was automatically extended to 3 minutes.

Experimental Results

For ^{48}Ca projectiles 233.2 ± 2.8 MeV energy six chains attributed to ^{270}Hs were detected for the beam dose of 3e+18. Cross section of about $8^{+6.7}_{-3.3}$ pb was measured for 4n de-excitation channel. Both 3n and 5n channel decay were not detected for beam doses of 6.2e+18 and 2.3e+18, respectively. The measured ^{270}Hs α-decay is equal to 9.02±0.08 MeV, that is in a good agreement with one, reported by TU München group [4].

Fig.1 Rotating target design view.

Discussion

Whereas the Grainer-Zagrebayev [2] calculation gives the 4n cross section value of about 30 pb, calculations by Adamyan et al. [3] show 3n channel as a dominating one; therefore, both models can not be considered as giving adequate description for given case. This measured parameter, undoubtedly, can be effectively used for rough extrapolations to higher Z, including those beyond Z=118 (Fig.2). For the case of Z=117 element a cross section value about ~ 1pb can be extracted from this empirical dependence. Of course, no any nuclear structure of the target is taken into account, so this extrapolation can be considered as to an only rough first approximation. Note, that the long term experiment ^{249}Bk + ^{48}Ca → 117+3,4n is in progress now at FLNR (JINR).

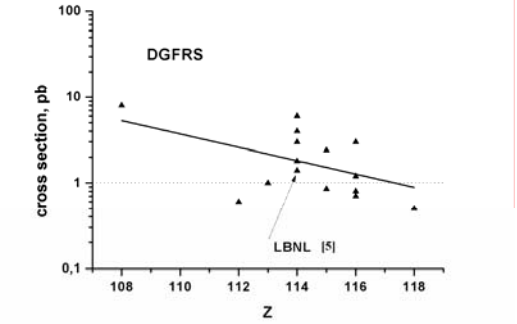

Fig.2 . The simple parameterization (trend) of effective cross section parameter for reactions with ^{48}Ca projectile. (Experimental points given for only 3 and 4n channels). Level of 1 pb is shown by dotted line.

Summary

The ^{226}Ra+^{48}Ca → ^{270}Hs + 4n heavy ion induced complete fusion nuclear reaction experiment has been performed at FLNR, JINR. The measured cross section value of about 8 pb can be used for extrapolation procedures. The ^{270}Hs α-decay energy is in agreement with one, measured by TUM group. Both 3n and 5n channels are not detected.

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